INT MISC

PROBLEM SELECTION STATEMENT
FOR
LINE PROJECT FS-INT-1601
STREAMFLOW REGULATION

The streamflow regulation project, headquartered at Moscow, Idaho, is titled "Streamflow Regulation in Northern Rocky Mountain Forests." It has two general research objectives: To determine quantitative relations of forest characteristics and timber harvesting procedures to snow accumulation and melt, streamflow peaks, sedimentation, and improved quantity and timing of water yields; and to use these relations as a basis for modifying or developing forest management and timber harvesting practices to reduce damaging streamflow peaks and sediment production and increase summer flow from the coniferous forests of the Upper Columbia and Missouri River Basins. This project is based on the critical need to manage these coniferous forests to improve quantity and timing of waterflow, and still not unduly increase streambank flooding in excess of what would occur naturally, or adversely affect the high quality of waterflow. Solutions to this problem, in the headwaters of these two important northerly river basins, may well have broad interregional significance in the Western United States.

Specifically, this project's mission involves research in the relations of forest characteristics and timber harvesting procedures to snow accumulation and melt, and movement and storage of water in the soil and over the soil surface; and to use these relations as a basis for modifying multiple use management and timber harvesting practices to bring about the desired regulation and high quality of streamflow under the impact of present timber harvesting. Essentially, the effort is pointed toward the safe disposition of increasing quantities of water as streamflow, following clearcutting of large acreages which is expected to increase substantially.

Problem Situation

Upper Columbia River Basin. The Columbia River discharges an average annual runoff of nearly 180 million acre feet from about 166 million acres. Of this amount, 41 million acre feet are produced on 35 million acres classed as forests within the boundaries of the Northern Region. Of the 35 million acres, almost 20 million acres of white pine, spruce-fir, grand fir-larch, and cedar-hemlock forests are in the heavy precipitation zone. These wet-zone, mixed-species forests receive from 30 to more than 60 inches of precipitation each year, and, therefore, generate the highest yield of water in the Northern Rocky Mountains, averaging about 14 area inches.

Almost three-fourths of the precipitation, mostly in the form of snow, falls during the season from October to April. Deep snowpacks accumulate

in the winter, and most of the snowmelt appears as streamflow during a short period in spring. Data from watershed inventory studies show that 73 percent of the annual flow occurs in March, April, May, and June. As a result, sections of the Columbia Basin, where reservoir storage is not feasible, have suffered recurring crop failures aggregating millions of dollars of loss because of inadequate irrigation supplies in late summer. Low winter flows have occasionally caused curtailment of power production, resulting in "brownouts" at various highly industrialized locations in the Pacific Northwest.

During the snowmelt season, rapid surges of runoff water lead to another continuing water problem--that of flooding. Although summer rains are light, fall rains usually recharge moisture in the soil mantle to near field capacity before the snowpack begins to build up. Later in the season, the deep snowpack melts rapidly during March through June--the months of heaviest seasonal rainfall. Consequently, soil mantles with limited storage capacity must dispose of larger amounts of water here than in any other part of the region. Historically, then, forest lands that produce the much needed quantities of water are considered the main source areas of damaging floods. Average annual flood damage along the Columbia River has been approximately 35 million dollars.

This flood situation has been aggravated since man has used the forest resources. For the past 5 years, regeneration cuts in the Northern Region have averaged 93,412 acres. Attendant road construction and skidtrails completely bare the soil on several thousands of acres. Cutting, in the future, will likely reach 130,000 acres annually. In addition, wildfire has destroyed forest cover on a vast acreage of land in the Northern Region. In the 40-year period from 1908 to 1947, more than 12 million acres burned--some areas two or three times. On some burned areas, new stands of timber have regenerated; but more than 2 million acres, that were subjected to multiple burns, are either unstocked or are very poorly stocked with young timber. A large part of this multiple-burned area lies in northern Idaho and western Montana.

When timber is removed from such large areas by logging clearcut blocks or when fire sweeps over entire watersheds, the intercepting, transpiring, and shading effects of the forest remain low for a period of 10 to 20 years--until new stands become established and crown closure develops. During this interim, the soil mantle inevitably receives as precipitation more water requiring disposal. Following removal or destruction of timber, transpiration of water (ranging from 15 to 24 area inches) and soil water storage opportunity in the soil mantle are reduced. This condition has led to substantial and aggravated streambank flooding in some forest lands west of the Continental Divide, as evidenced by ripped channels and washed-out roads and culverts. The

normal storage capacity of forest soil is also reduced by removing litter and humus normally incorporated within upper soil layers. This may be caused by roadbuilding, log skidding, fire, or erosion. The resulting increase in overload flow accentuates the potential for larger flood peaks and rapid erosion.

Research results reveal that, among the factors affecting erosion and sediment production from logging roads, water stable aggregation of the exposed surface is one of major importance. The most erodible soils of the Upper Columbia Basin, in decreasing order, are those derived from loess, glacial silt, and granitic rocks.

Annually the Columbia River carries a sediment load estimated at about 19 million tons. This is considerably less than what other major river systems of the West carry, but still enough to create substantial damage to downstream water-handling structures. Undoubtedly, a large portion of this sediment originates on the agricultural lands of the Columbia Basin. How much sediment is produced from forested lands, and particularly from those that have been placed under management, is not readily discernible. It is of a sufficient amount, however, to cause upstream damage to sport fisheries--especially the highly valued spawning beds of the Clearwater and Salmon River tributaries.

Upper Missouri River Basin. The Missouri River discharges an average of about 59 million acre feet of water annually from a drainage area of 339 million acres. Of this amount, approximately 17 million acre feet originate on about 82 million acres of land in the Northern Region. Thus, the Missouri River discharges approximately one-third as much water from about twice as great an area as does the Columbia River. About 70 percent of the land area in the Upper Missouri River drainage receives less than 15 inches of precipitation annually. Only about 1 percent receives more than 20 inches, hence the runoff production per acre is very low. By comparison, in the Columbia Basin, 27 million acres produce from 5 to 40 inches of runoff; while in the Missouri, about 9 million acres produce from 5 to 20 inches of runoff. The flow of the Missouri River differs markedly from that of the Columbia, except in the small headwater tributaries which have steep gradients. Many tributaries are large and long and their flow, like that of the main Missouri, is slow and sluggish.

The most significant climatic feature of the Upper Missouri Basin is the great variation in precipitation from year to year, especially on the plains of eastern Montana. Here, precipitation varies annually from less than 30 to more than 200 percent of normal. Well over one-half of the annual precipitation of 10 to 15 inches, in this section, comes as rain during summer. Much of this precipitation is lost by rapid overland flow that carries large amounts of sediment. In the

higher mountains and valleys of the western part of the basin, where the main plant cover is lodgepole pine and grass-forbs, much of the annual precipitation is snow. Although occupying only 3.7 million acres or 4 percent of the Missouri Basin, this part constitutes a vitally important source of water.

Water shortages occur throughout the Missouri Basin about 1 year in 10. Shortages occur locally within the basin almost every year. Those streams having steep profiles, as well as the major tributaries, provide little opportunity for storage of surface water. About 75 percent of the annual streamflow is discharged by early July; hence, upper basin irrigation often depends upon direct diversions of variable and, often, inadequate, streamflow in summer and fall.

Floods have occurred more frequently in the Missouri than in the Columbia River. Average annual flood damage has averaged nearly 148 million dollars. Annually, an estimated 200 million tons of sediment is carried down the Missouri River. A variety of climatic conditions may cause these major floods: rapid snowmelt, often accompanied by heavy rain; and, in the plains region, snowmelt and/or rainfall on frozen soil.

Until recently, relatively little lodgepole pine timber was cut in the high water-yielding zone. Increasing demands for lumber and improved techniques in wood utilization have combined to accelerate timber harvesting from these forests during the past few years. This has increased the cut to approximately 4,700 acres annually. In the future, the annual acreage of cut will probably remain small compared to the 10's of thousands of acres logged over each year west of the Continental Divide. Although the flood potential aggravated by timber removal and land denudation in the Upper Missouri Basin will increase, it is expected to be at a much slower rate.

Silvicultural conditions favor clearcutting of lodgepole in large blocks. These forests are infected with the disease dwarfmistletoe, that develops most intensively close to clearcut borders. Large clearcut blocks would tend to reduce the perimeter exposed to infection, but they would also tend to increase the hazards of higher runoff peaks and erosion. Dolomitic soils are the most critical areas in lodgepole pine forests because they are most extensive and can produce large quantities of sediment when disturbed.

General Considerations. Major floods and water shortages occur because of untimely streamflow distribution. Sometimes there is too much; at other times, too little. Both of these situations have been alleviated somewhat on the Columbia and Missouri Rivers by construction of storage dams to regulate downstream flow. Projects proposed for both rivers should aid materially in solving flood control and water shortages.

Despite this, two problems remain that storage and streamflow regulation by big dams will not solve. One of these is continuing sedimentation, with its attendant depletion of storage capacity and its high maintenance costs. The other is inability of large dams to prevent flood discharges and water shortages upstream, where sizable investments exist in both rural and urban developments. Methods of managing forest lands to regulate effectively streamflow quantity, timing, and quality must be found through research--if the useful life of expensive downstream structures is to be protected and if important upstream areas are to be spared from water shortages and floods.

Project Mission Problems

An examination of the project mission reveals two distinct problems needing research. Essentially, they are keyed out on a broad geographical basis--namely, the Upper Columbia River Basin and the Upper Missouri River Basin.

Problem 1. Achieving streamflow regulation and sediment reduction in the coniferous forests of the Upper Columbia River Basin. This problem stems from a combination of abundant precipitation on forested lands and from management practices applied extensively over a large area each year which remove virtually all major vegetation, thus reducing drastically the transpirational draft on soil water and reducing infiltration on areas of major disturbance. The net effect is a substantial increase in water yielded as streamflow--a desirable management objective. But, because of the need for maintaining this objective, our major effort must be directed to finding means of insuring safe disposition of this increased runoff through desynchronization of streamflow. Essentially, we hope to broaden the base of the hydrograph in both directions from the period of peak flow, with no aggravation and possibly a reduction in peak discharge. This should result, at the same time, in increasing late summer flows, in maintaining stream channel stability, and holding siltation to a practical minimum. The specific problem area is confined to the deep snowpack, mixed-species forests that receive more than 30 inches of precipitation each year. Here, almost three-fourths of the precipitation is held temporarily in the form of snow, thus affording an excellent opportunity for affecting regulation.

Problem 2. Improving quantity and timing of water yields and sediment reduction in coniferous forests of the Upper Missouri River Basin. The main scope of the problem east of the Continental Divide centers in controlling of sediment and delaying runoff further into the summer for direct diversion, because of the scarcity of facilities for storing early runoff. Methods developed for delaying runoff should also include means of increasing the total water yield. Very likely,

the research techniques and proposed management practices developed under Problem No. 1 would serve as research guides and, in some cases, be applicable directly to eastside conditions. However, broad extrapolation of research findings from the Columbia Basin would likely prove invalid and risky because of major differences in geomorphology, soils, climatic patterns, and timber species. Therefore, Problem No. 2 is of sufficient importance to be considered separately. Major work will be done in the high water-yielding lodgepole pine and associated species type which occupy 2.5 million acres in central and east-central Montana. Almost one-half of the total precipitation occurs as snow, an amount one-fourth less than what occurs west of the Continental Divide.

Problem Selected for Study

Problem No. 1 has been selected as the first to receive primary research attention with our present staffing. The local need for solving water problems is equally acute in the headwaters of both river basins. However, the early solving of the problem in the Upper Columbia Basin will undoubtedly affect more people, more industry, and more agriculture values by the year 2,000. The Columbia River system ranks second only to the Mississippi in volume of flow; the potential capacity for hydroelectric power is estimated at nearly 34 million kilowatts or 40 percent of the nation's total estimated potential; and presently about 4 million acres are under irrigation, while comprehensive plans include irrigation of 3.8 million additional acres and supplemental water for 1.5 million acres now irrigated. As a consequence, huge population centers are developing within a radius of 150 miles of the river's mouth; while along the upstream reaches more intensive use is being made of the streamside zone by industry, urban population, and recreationists than is being made east of the Divide.

The market demand for forest products within the Upper Columbia Basin is far outdistancing a similar demand in the Upper Missouri Basin. In fact, the conversion from the decadent old-growth conditions to vigorously growing young forests proceeds at a pace 19 times greater than east of the Divide. Therefore, the need for incorporating into present cutting practices schemes that will regulate streamflow looms greater each day. Postponing research and management application may bring about irretrievable changes in the structure of new timber stands that cannot be rectified until the beginning of the next stand rotation, 80 to 120 years hence. Because of the slower pace in converting stands east of the Divide, delay in activating research is not quite as serious.

Since 1948, several water resource plans have been proposed involving regional or interregional distribution of water produced within the confines of the Columbia River system. One plan of monumental importance proposes a transbasin diversion of millions of acre feet of

"surplus" water to the southwestern region of the United States. If this water plan becomes a reality through coordinated State-Federal legislation, high premium will be placed on each additional acre foot produced west of the Continental Divide in Montana and northern Idaho.

For these reasons, based primarily on economic consideration, we are concentrating our limited effort on the problem in the Columbia River Basin.

Additional characteristics of this problem that emphasize its priority follow:

The project is presently headquartered at the new Forestry Sciences Laboratory on the campus at the University of Idaho. Plans for the second phase of the laboratory building call for expanded office-laboratory-storage facilities for the watershed project. In addition to the advantages of being located on the Idaho campus, we are but a short distance from Washington State University--with its excellent library and computer center. Both universities have schools of forestry, with newly formed departments of watershed management; therefore, opportunities of cooperative research with staff or graduate student assistance are present.

To the north of Moscow lies the Priest River Experimental Forest, operated yearlong by resident technicians. The 6,368-acre site affords excellent outdoor facilities for snow management research; it is also readily accessible. To the south, in the Nezperce National Forest, the Meadow Creek barometer watershed includes a pair of large, operable subdrainages in Horse Creek now undergoing joint study by Region 1-Nezperce N.F. and watershed management Project 1601. Close proximity of this study area, as well as the excellent cooperation given our researchers by Region 1 and the Nezperce staff, have materially aided the total research effort.

In summary, the selection of Problem No. 1 as first priority is based on: (1) The urgent need for research findings that can be applied to forest lands within the largest river system in the Western United States; (2) the numerous advantages of being located on or near two major land-grant universities; (3) the close proximity of two ideal work areas; and (4) the excellent cooperation developed with both the Regional and National Forest staffs.

Segments of the problem of streamflow regulation and maintenance of water quality within the mission of Project 1601 fall into three categories:

1. What are the point and spatial relations that forest land components, i.e. vegetation, soil, land form, aspect, and elevation, have on the disposition of water in three strata: (a) in the atmosphere, (b) on the land surface, and (c) in the underground mantle?

2. To what extent can manipulative treatments be applied to forest lands to alter significantly the disposition of water in one or more of the three strata?

3. By what means can ecological and hydrometeorological predictors of the spatial effects of unmanaged and managed forest land be equated to predict streamflow phenomena of small drainages and tributary networks?

The broad plan of research under this project calls for investigations in the Priest River, Lochsa River (site of short-term study), and Horse Creek areas. Work will be extended to other areas as required and conditions permit.

To determine the point and spatial relations of forest land requires studies that fill the gaps in our knowledge of the physical and hydrologic processes involved in the disposition of precipitation from the time rain and snow fall onto the land surfaces until it reappears in the form of streamflow.

Studies of manipulative treatments, e.g., the location and geometry of cutting patterns or the location and drainage design of roads or other more sophisticated means, will be directed toward delaying or enhancing rates of snowmelt and transmission of water to stream channels.

Application of basic hydrologic-ecologic knowledge and practical manipulative treatments will be studied on large, operable watersheds in the attempt to develop prediction techniques adaptable to the management of large areas of forest land.

Some inventory work will be kept concurrent on Problem No. 2. This effort will be limited to basic mineral, soil, and timber survey work in the Tenderfoot Creek Experimental Forest, south of Great Falls, Montana. Lack of financing precludes more detailed work on this problem at the present time.

Coordination

Common interests and related objectives exist between the Moscow Project 1601 and Boise Project 1602. Project 1602 is concerned primarily with the restoration of soil stability following onsite soil disturbance caused by the total operation of logging on granitic soils of

the Northern Rocky Mountains. An area of relatedness exists in the occurrence of sensitive soils in both project areas. Until 1962, considerable work was done on erosion from logging roads in the Northern Region as part of Project 1601--Problem No. 1. Henceforth, research on erosion from roads and methods of stabilizing logging disturbance will be restricted to coordinated ventures initiated by Project 1602. Project 1601 will continue to study bedload movement and channel stabilization as affected by streamflow regulation.

The assigned missions of INT Projects 3701 (Engineering Systems for Steep Mountain Forestry), 1201 (Silviculture of Western White Pine), 1203 (Silviculture of Lodgepole Pine), and 1204 (Silviculture of Western Larch and Engelmann Spruce) need to be considered as they may relate to Project 1601. Project 3701 scientists will be consulted and briefed on matters pertaining to logging road design as it affects streamflow regulation, and any work in this field will be coordinated. Recently, personnel of Project 3701 expressed a desire to study the economic aspects of road engineering as part of the long-term Horse Creek study. Project 1601 will coordinate and collaborate with the three silviculture projects when questions arise as to the influence cutting patterns and block design may have on other silvical aspects.

Finances

The gross budget for this project in F.Y. 1966 is $52,158. This provides two full-time scientists, one full-time forestry aid, and the part-time services of the Priest River Experimental Forest superintendent and a forester assigned to the Nezperce National Forest. Staffing with six full-time scientists and an equal number of technicians or aids is planned when appropriations permit.

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